FORCE SYSTEMS

2/4 MOMENT

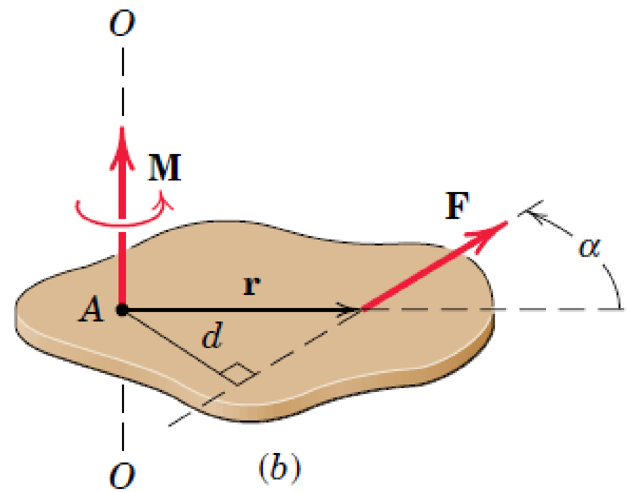
- In addition to the tendency to move a body in the direction of its application, a force can also tend to rotate a body about an axis.
- The axis may be any line which neither intersects nor is parallel to the line of action of the force.
- This rotational tendency is known as the ***moment*** **M** of the force. Moment is also referred to as ***torque.***
- the magnitude of the moment is defined by

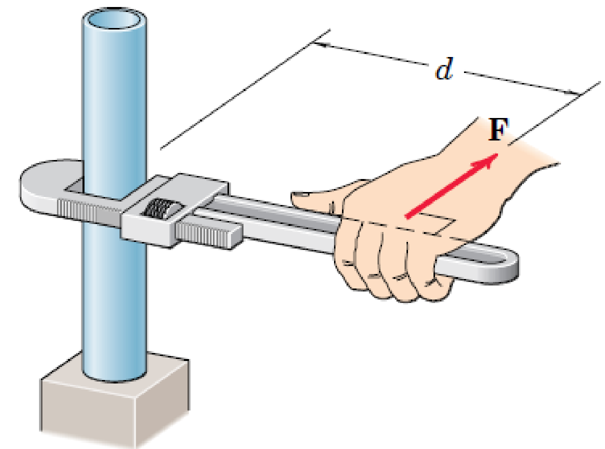
$$M = Fd$$

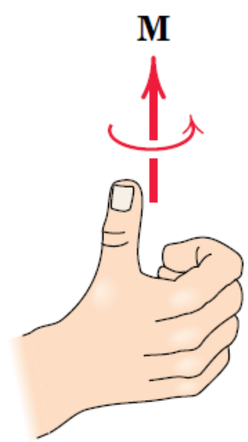
- The right-hand rule is used to identify this sense

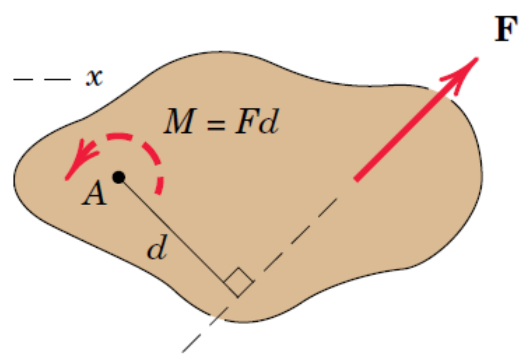
FORCE SYSTEMS

The magnitude of this tendency depends on both the magnitude ***F*** of the force and the effective length ***d*** of the wrench handle.



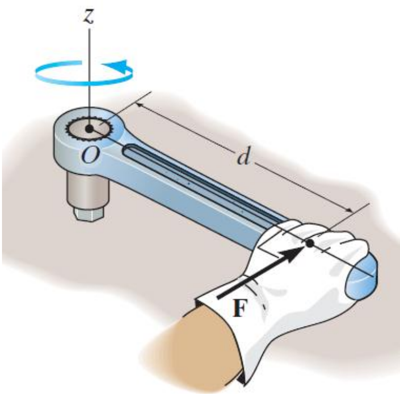




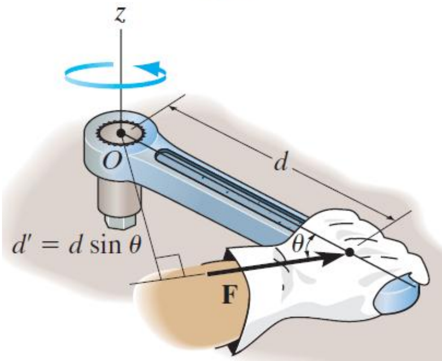


FORCE SYSTEMS

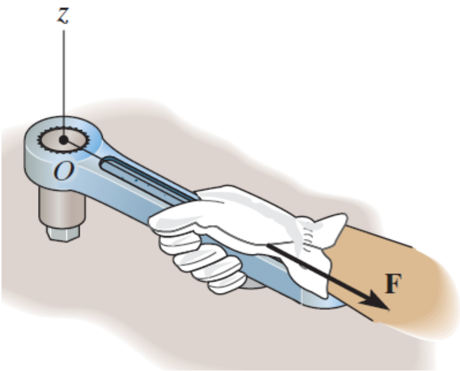
- If the force **F** is applied at an angle $\theta \neq 90$, then it will be more difficult to turn the bolt since the moment arm $d' = d \sin \theta$ will be smaller than d.



- If **F** is applied along the wrench, its moment arm will be zero since the line of action of **F** will intersect point O (the z axis).



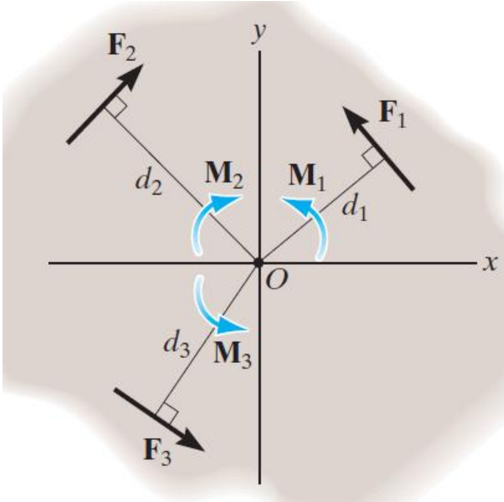
- As a result, the moment of **F** about O is also zero and no turning can occur.



FORCE SYSTEMS

Resultant Moment.

The resultant moment $(M_R)o$ about point ***O*** **(the *z* axis)** can be determined by *finding the algebraic sum* of the moments caused by all the forces in the system

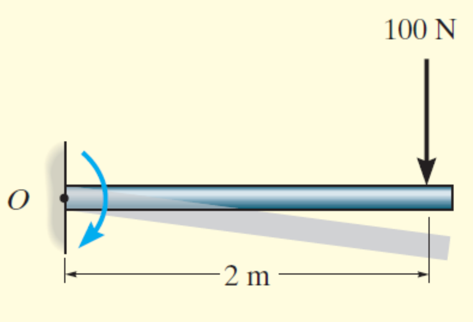


$$\circlearrowleft + (M_R)_o = \Sigma Fd; \qquad (M_R)_o = F_1 d_1 - F_2 d_2 + F_3 d_3$$

If the numerical result of this sum is a positive scalar, $(M_R)o$ will be a **counterclockwise** moment and if the result is negative, $(M_R)o$ will be a **clockwise** moment

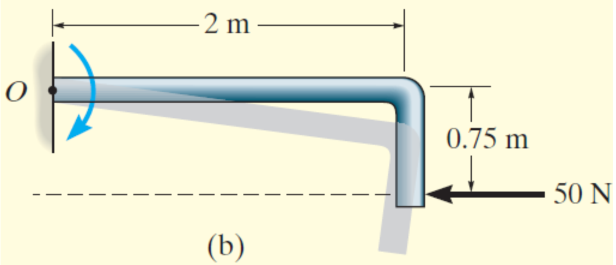
Ex:- For each case illustrated in Figures, determine the moment of the force about point *O*.

$$M_O = (100\ \text{N})(2\ \text{m}) = 200\ \text{N}\cdot\text{m}\ ↻$$



(a)

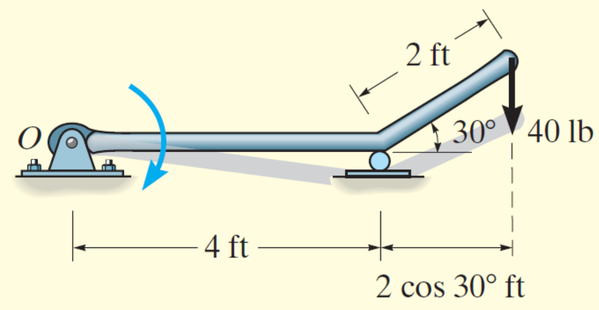
$$M_O = (50\ \text{N})(0.75\ \text{m}) = 37.5\ \text{N}\cdot\text{m}\ ↻$$



(b)

$$M_O = (40\ \text{lb})(4\ \text{ft} + 2\cos 30°\ \text{ft})$$

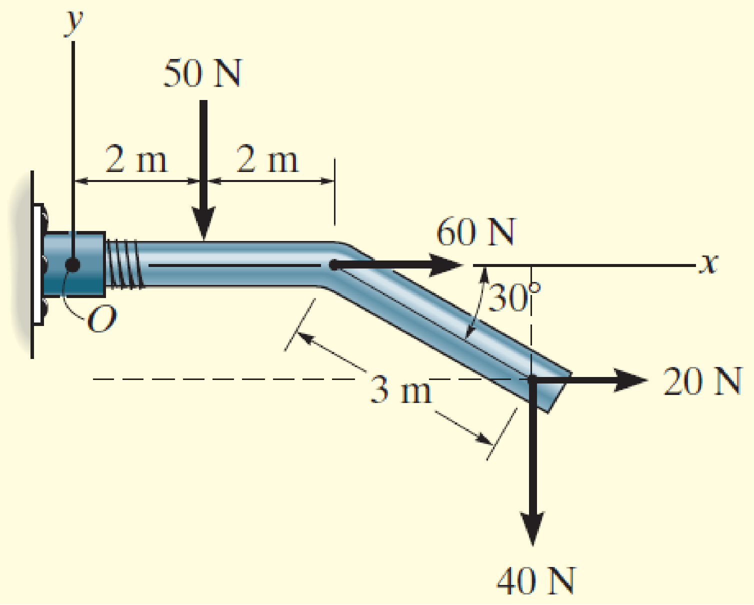
$$= 229\ \text{lb}\cdot\text{ft}\ ↻$$



(c)

FORCE SYSTEMS

Ex:- Determine the resultant moment of the four forces acting on the rod shown in Figure about point *O*.



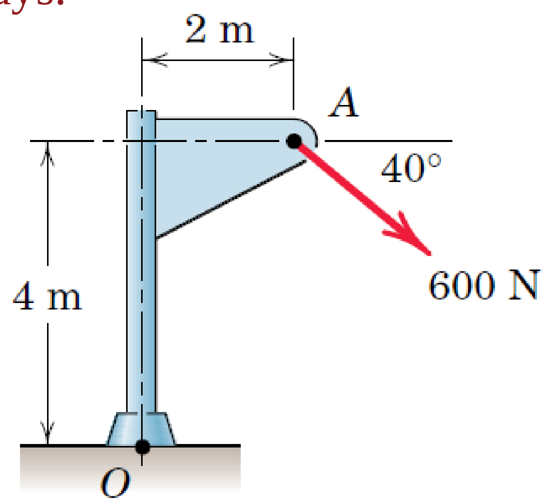
$$\circlearrowleft + M_{R_O} = \Sigma F d;$$

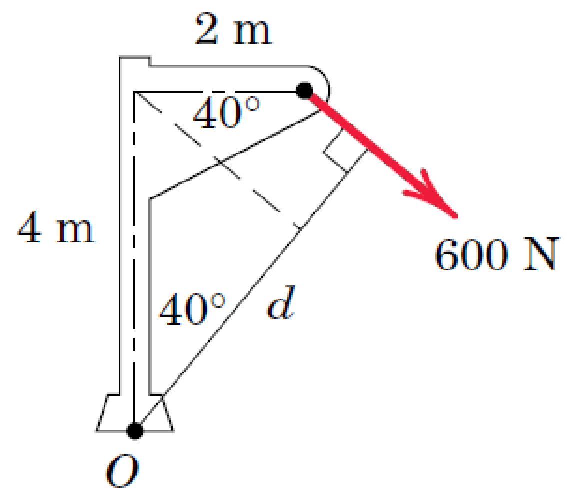
$$M_{R_O} = -50\text{ N}(2\text{ m}) + 60\text{ N}(0) + 20\text{ N}(3\sin 30^\circ\text{ m})$$

$$-40\text{ N}(4\text{ m} + 3\cos 30^\circ\text{ m})$$

$$M_{R_O} = -334\text{ N}\cdot\text{m} = 334\text{ N}\cdot\text{m}\circlearrowright$$

Ex:- Calculate the magnitude of the moment about the base point *O* of the **600-N** force in five different ways.



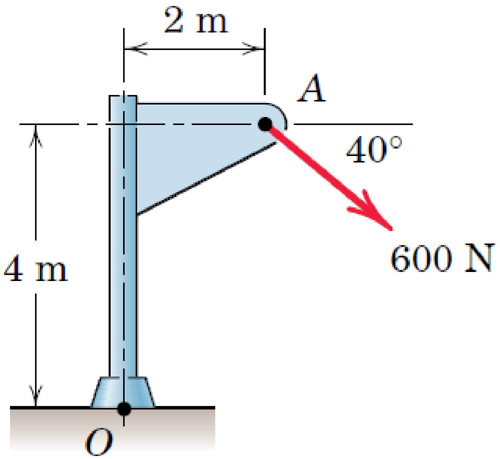


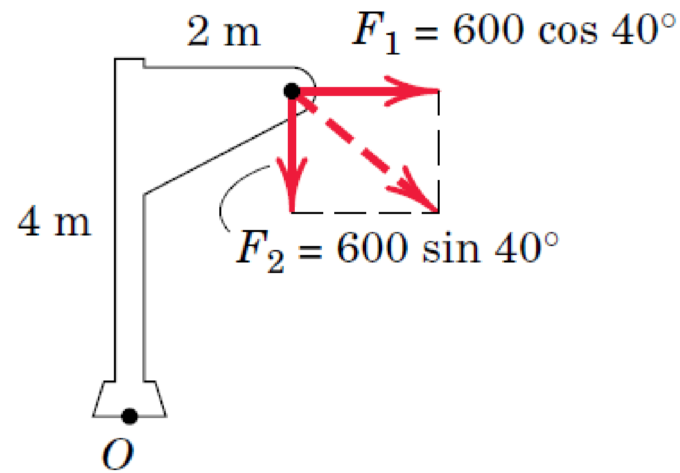
Solution. *(I)* The moment arm to the 600-N force is

$$d = 4 \cos 40° + 2 \sin 40° = 4.35 \text{ m}$$

By $M = Fd$ the moment is clockwise and has the magnitude

$$M_O = 600(4.35) = 2610 \text{ N}\cdot\text{m}$$





(II) Replace the force by its rectangular components at A

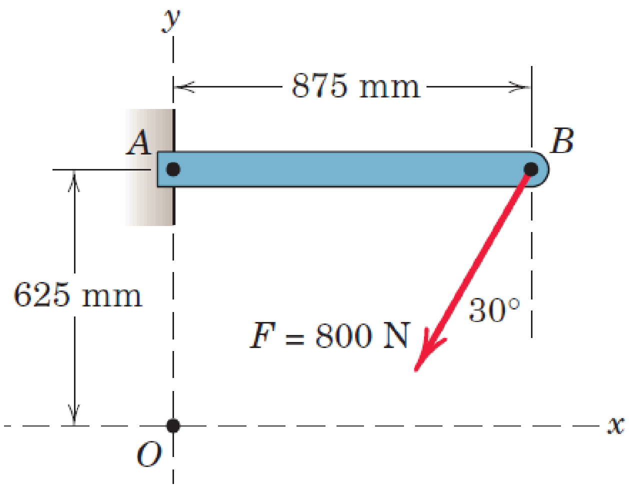
$$F_1 = 600 \cos 40° = 460 \text{ N}, \qquad F_2 = 600 \sin 40° = 386 \text{ N}$$

By Varignon's theorem, the moment becomes

$$M_O = 460(4) + 386(2) = 2610 \text{ N}\cdot\text{m}$$

H.w.

Q1:- Determine the moment of the **800-N** force about point *A* and about point ***O***.



Q2:- **(*a*)** Calculate the moment of the **90-N** force about point ***O*** for the condition $\theta = 15$. Also, determine the value of for which the moment about ***O*** is **(*b*)** zero and **(*c*)** a maximum.